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APRIL 1963

USES OF
AUTOMATED FORCE COST MODELS

R. N. Grosse and A. Proschan

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PREFACE

In the course of accomplishing the transfer to the Department of the Army of the automated force cost model developed by RAND under the supervision of the Office of the Assistant Secretary of Defense (Comptroller), meetings were held with an Army cost model team at which the various features of the model were explained and related written materials were furnished. This Memorandum presents the substance of the presentation on the potential uses of a force cost model in the context of Army management needs. Additional information on the cost model is provided in two other RAND publications:

R. N. Grosse, Army Cost Model, RM-3446-ASDC, December 1962; and

A. J. Meltsner, Information Requirement Problems for Army Force Structure Cost Analysis, RM-3468-ASDC, February 1963.

SUMMARY

An automated force cost model is a device for rapidly computing resource and cost requirements of force specified as to its composition in force units, deployments, ι ιιpping and manning levels, and numerous other cost-affecting chara teristics. The newly established planning-programming-budgeting cycle in the Department of Defense has created a greater demand for resource and cost estimating, and this has brought cost modeling into greater prominence. While actual operating experience with cost models has thus far been largely confined to the planning phase, there are substantial uses that can be visualized for models in programming and budgeting as well.

After a discussion of the uses of cost models in planning, this Memorandum outlines the several uses in programming and budgeting, both as alternates to estimates by program managers and as adjuncts to them.

CONTENTS

I. INTRODUCTION

What do we understand by the term "automated force cost model"?
A force cost model is a system of relationships and data from which are
computed the incremental time-phased resource and cost requirements for
the equipping and operating of a force.(This is equivalent to what is
done by program managers in the course of budget formulation.) For
reasonably accurate estimates, we must have a specification of the
controlling factors - force composition, equipping levels, replacement
rates, activity levels, etc. (This is generally equivalent to program
guidance.)

A force cost model cannot simply aggregate weapon and support
system costs, since such costs are interdependent, but must reach down
into the requirements for personnel, equipment, services, and facilities
as determined in the context of the entire force. The cost of a system
or indeed any item or alternative, is calculated by pricing out the
force twice - once with the change proposed and once without - the
cost of the system being the computed difference in total costs.

An automated force cost model is one for which the use of data
processing equipment permits many of the calculations to be mechanically
performed. The utility of automation is indicated by the fact that a
force of any real size is characterized by thousands of items relevant
to a computation.

Cost models at the current level of sophistication can hardly be
expected to generate answers for such programs as research and develop-
ment in the same fashion as materiel requirements are determined on

the basis of numbers of force units and related data. In general, requirements for research and development and other such programs must be determined outside of the model, and treated as thruputs in the development of total costs by means of the model.

We may distinguish two major uses of automated force cost models: (1) for planning of alternative force structures and employments; and (2) for programming and budgeting. The planning use was first in time, and by now considerable operating experience has been gained. With the introduction of the DOD programming system the potential utility of force cost modeling for programming and budgeting has grown to the point where we can reasonably anticipate that before long force cost modeling will be as important for programming and budgeting as for planning.

Let us first consider the use of force cost models as a tool in planning.

II.   PLANNING USES

Military planning of forces, deployments, and equipments has long been a primary function in the defense establishment. Emerging from this planning have been force and equipment requirements over periods of time ranging up to ten years and more. These requirements have in many cases been developed with only a minimum regard for cost, the ingredients of the planning kit being intelligence estimates, technological trends, tactical experience, etc. It has on occasion been a particular emphasis in military planning to exclude resource considerations - to arrive at pure requirements.

The great rapidity of technological advances has given military planners far more alternatives to choose from. In broad problems the most feasible solutions are often mixes of different systems and forces. It has become increasingly apparent that the selection of the most desirable mix should realistically involve cost as a major element. Mr. Hitch has explained the importance of cost in these words:*

> Furthermore, there has long been a tendency in the Defense
> Department to state military requirements in absolute terms
> without reference to their costs. But the military effec-
> tiveness or military worth of any given weapon system cannot
> logically be considered in isolation. It must be considered
> in relation to its cost - and in a world in which resources
> are limited, to the alternative uses to which the resources
> can be put. Military requirements are meaningful only in
> terms of benefits to be gained in relation to their cost.
> Thus, resource costs and military worth have to be scrutinized
> together.

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*Testimony in Systems Development and Management (Part 2), Hearings before a Subcommittee of the Committee on Government Operations, House of Representatives, 87th Congress, 2d Session, U.S. Government Printing Office, Washington, 1962, p. 515.

Cost has been ground into military planning in the form of what
are called cost-effectiveness studies. The objective of these studies
is to determine the most effective military capability for a given
cost, or the least cost at which a desired level of military capability
can be achieved. As explained by Mr. Hitch in the testimony referred
to above, in such studies it is necessary to:

(a) Define objectives;
(b) Lay out alternative ways of accomplishing the objective;
(c) Calculate how effectively each alternative accomplishes the
    objective; and
(d) Calculate how much each alternative costs.

Acceptance of this way of approaching military planning has been
greatly accelerated in the last two years by the McNamara-Hitch emphasis
on development and maintenance of a five-year program based at least in
part on cost-effectiveness studies. Not only has OSD initiated such
studies on its own, but it has given impetus to studies of this kind
being performed as an essential element in the service's own planning.
This emphasis is natural in view of the personal experience which
Messrs. McNamara, Hitch, and others in OSD have had in the systematic
weighing of alternatives in terms of their costs and benefits.

How is cost used in cost-effectiveness studies? To be realistic
we must cost and compare the particular forces under consideration in
terms of net incremental requirements for manpower, facilities, and
dollars, starting with the force in being and allowing for the effects
of time. We need relative rather than absolute accuracy, since the
costs are used to compare alternatives. Nevertheless, we must have
a fairly good specification of the force; and our answers must be
sufficiently detailed by kind and timing of cost to give us a meaningful

basis for comparison of forces or employments. Since any one problem
may involve two to a dozen alternatives, and others may suggest them-
selves in the course of the problem, a very large volume of costing
may be required.

Such costing has been performed by RAND in its Air Force cost-
effectiveness studies, and over the years many force cost estimates
have been developed under a variety of assumptions. The magnitude of
the workload and the need for rapidly arriving at answers led in early
1958 to the application of automatic data processing to the completely
manual methods then in use. This experience has been a major factor
leading to the assignment to develop the Army cost model, as one of
a series planned by OSD. Even before the initial version of the
Army cost model was completed, it became necessary for OSD to cost a
variety of force mixes. In the absence of this model, RAND had to
improvise for OSD a cruder version.

The Army has also recognized the need for an automated cost model
to assist in planning and programming by establishing within the AUTOPROBE
system Task No. 11, Coordinated Planning and Programming Support System;
and by its present efforts to evaluate and assimilate the Army cost model
developed by RAND.

We do not wish to create the impression that all cost-effectiveness
studies require force cost models for the derivation of costs. Many
problems are sufficiently narrow in scope to lend themselves to more
limited costing techniques. Nevertheless, for many of the more
important studies, force cost models represent the best approach to
costing.

III. PROGRAMMING AND BUDGETING USES

In regard to use of a cost model for programming and budgeting, we do not have nearly as much operating experience. Nevertheless, we feel that a convincing case can be made. Let us first summarize some key features of the new programming process.

For planning and programming purposes, defense programs are classified into an output-oriented (weapon/support system and force unit) program element structure. For each program all related costs are aggregated, including the cost categories of research and development, investment, and operations. It is in terms of these classifications that a Five-Year Force Structure and Financial Program is maintained on a continual basis, for a period extending five years beyond the current year. Within each of the cost categories, financial data on an obligational authority basis is directly relatable to the Defense appropriations. The budgetary implications of the five-year plan are thereby readily determinable.

The five-year plan is maintained current through the medium of the program change control system, which requires the Secretary's approval for changes exceeding the designated "threshold" criteria; and through periodic updating of all program elements.

An annual comprehensive review is to be used as a prelude to major decision-making on the newer programs.

The new programming process requires frequent cost estimating of approved programs in program element terms, both for periodic updatings of estimates and for recognizing significant deviations from previously approved levels which require program change proposals under the program change control system. These cost estimates must be in standard appropria-

tion as well as program element terms in order to permit translation of approved programs to budgets.

Sufficient accuracy in costing is required to make the Five-Year Force Structure and Financial Program a valid instrument for top-level decision-making, for program control, and for derivation of annual budgets. This means that for the current and budget years, estimates should be of the quality associated with budget formulation and administration. For subsequent years, estimates can be based on broader planning factors than are customarily used in budget formulation, subject to the requirement that such estimates can in time be converted to budget estimates with no substantial differences.

Let us consider the process of cost estimating from the initial program guidance to the end-product consisting of a Five-Year Force Structure and Financial Program. For discussion purposes, it will be helpful to reverse the process and start with the object of the exercise, the five-year plan.

OSD expects from the Army a five-year plan expressed basically in terms of the items on the Program Element Summary Data formats, together with a machine-readable version of the data to permit OSD to keep a mechanical file of its own for comparisons and summaries. When OSD talks of an automated five-year plan, it is generally referring to the machine-readable data submitted by the services and to their incorporation in a mechanical file. Observe that the data consist of answers developed by the Army and the other services; OSD using these data is not able to develop the cost estimates itself.

Certainly the Army has recognized the need to maintain for itself a mechanical file of the kind we have been describing. The Army has recognized the need of automating at least one stage in cost estimating preceding the final answers, and that is the attribution to program elements of the costs developed on a net basis for the Army as a whole.* In effect, the Army takes the five-year estimates developed in much the same fashion as budgets are developed, and then applies various rules to ascribe or allocate these budget estimates to the program elements which are regarded as generating the cost requirements. This permits the continuation of cost estimating according to the traditional budget process, with conversion to program elements being a subsequent task performed very probably under a higher degree of centralized control than the basic estimates themselves.

At this point let us return to our Army cost model and say that a similar process must be performed in cost modeling - the attribution of cost to program elements. It is significant that in calculating costs through cost modeling we develop the costs through the use of a program element structure (actually the major force units within the program elements) and therefore there is less need for allocation later. We will return to this point a little later.

As we have indicated, the stage preceding the attribution to program elements is the performance of cost calculations, accomplished mechanically in the cost model and largely manually by the Army.

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Why would the Army want to bother with cost models when it can
pull together budget estimates from the various program managers?
In attempting an answer, let us distinguish between cost modeling as
an _alternative_ to manual budget estimating, and cost modeling as an
adjunct to manual budget estimating.

There is a number of arguments for cost modeling as an alternative
to manual cost estimating. First, we must recognize that the programming
process greatly increases the burden of estimating. Since five years
rather than one are involved, costs must be expressed in program element
as well as in appropriation terms, and more frequent estimates are re-
quired for updatings and program change control. Some degree of auto-
mation naturally suggests itself in this area - if it were practicable
to achieve mechanically cost estimates of the required degree of accuracy.
We regard our cost model as a long step in this direction, though we
are well aware of the limitations in accuracy of the initial version.

As in the case of broad-scale planning of the kind previously
discussed, we may desire or be forced in programming to consider various
possibilities of a sensitive nature. If we publicize these in the course
of getting manual budget estimates, we may create a good deal of unnecessary
concern and even confusion. Computed in a cost model, these possibilities
need not be publicized at all to the program managers, so that they can
keep their attention focused on the approved program. This, then, is
another argument for cost modeling - the ability to avoid unnecessary
dissemination of sensitive matters.

A condition affecting manual budget estimating in program element terms is the lack of parallelism between the Army management structure and the program element structure. The Army management system must be geared to a variety of considerations, of which actual administration ranks high. The program element structure is primarily designed for top-level decision-making on the application of resources. The two concerns are not identical. In farming out budget estimating assignments to program managers, some awkwardness is inevitable because of this difference in structures, and that is why so much allocation of costs to program elements becomes necessary as a subsequent operation.

A cost model can more easily be conformed to the program element structure than can the Army management system, and so costs can be more directly derived in program element terms. It seems reasonable to expect that the greater the extent to which costs are actually developed by program element, the more accurate costing by program element can be made.

So much for the arguments for cost modeling in lieu of budget estimating by program managers. Now let us consider the arguments for cost modeling as an adjunct to budget estimating by program managers. This brings us to the stage preceding budget and cost calculation - the program guidance governing the estimating. When program managers are required to develop estimates, they are of course required to conform to the program guidance. This guidance is often of a rather general nature, and the program managers are expected to lean heavily on prevailing practice and judgment. Especially since five years are involved in programming as against one in budgeting, there are more gaps in the program guidance and more latitude for the program managers. Also to be considered is the fact

that the guidance must be there for exercises at various times during
the year, whereas in budgeting we are concerned generally with a once
or twice-a-year exercise.

In cost modeling we cannot tell the computer to exercise judgment -
unless we can say just how this judgment should be exercised, which is
equivalent to establishing some very specific decision rules. Cost
modeling therefore casts a very revealing light on the adequacy of
program guidance. Even our first Army modeling effort has afforded
us considerable insight into the underlying program guidance - trans-
mitted in a separate publication.* Even if the Army continues to place
its main reliance on estimates by program managers, cost modeling will
help toward the development of comprehensive program guidance to control
the estimating process.** At present, the Army would have a very extensive
process to go through to learn from program managers just what assumptions
they based their estimates on. This is laborious enough when performed
in the course of budget formulation; the greater frequency and time
coverage of programming estimates would make the problem even worse.
We may therefore say that cost modeling affords a degree of control
over the process of developing comprehensive program guidance.

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*A. Meltsner, Information Requirement Problems for Army Force
Structure Cost Analysis, The RAND Corporation, RM-3468-ASDC, February
1963.

**One of the objectives in revising the Army Program System is "to
establish procedures for providing complete and timely guidance to commands
and operating agencies in terms which will permit the proper application of
available resources to achieve stated program objectives, i.e., to relate
missions and resources as closely as possible." Quoted from Revision of the
Army Program System, Initial Orientation Manual, Office of the Chief of
Staff, Department of the Army, Nov. 15, 1962, p. 29.

Cost modeling has the further advantage of actually assuring conformity with approved program guidance. This point requires no elaboration. Related to this is conformity with approved costing methods. Cost modeling depends on very explicit factors and cost estimating relationships which are readily displayed to us in the various input and analytical output listings. It is much harder to ascertain from program managers just how they arrived at their estimates. Cost model outputs can be very helpful in providing a base against which to evaluate program manager estimates. Priority attention can be given to the most significant deviations and thereby our programming and budgeting reviews can be made more efficient; we know where we need to give our closest attention. We can check the factors and estimating relationships used by program managers against those used in the cost model, and more readily understand just where the program manager and the model applied different approaches. In short, we have in the cost model a tool for beginning, at least, the process of validating program manager estimates.

Some of you may be familiar with the Secretary of Defense project which involved a review of budgetary factors to be used in the preparation of the FY 1965 budget. The input and analytical output listings of the cost model provide a convenient basis for getting at such factors. This brings us to the next argument for cost modeling as an adjunct to manual budget estimating, the value of documentation derivable in cost model operation.

Through the display of factors, allowances, and other data just mentioned, the cost model provides a systematic basis for updating and revision, and a starting point for organizing research toward improved

costing methodology. What is involved here is not a catchall data bank
into which we put everything we know, without being quite sure as to how
we will use the data, but a data bank for which we know exactly how
each item of information will be used. We have more motivation, there-
fore, to establish systematic procedures for updating and improvement.

The documentation through the cost model of major item requirements
by force unit is of value in permitting us to continually relate the
planned procurement to potential users. We know thereby how our future
assets can be distributed upon receipt, and in effect, what we may expect
in regard to the future readiness of the forces (insofar as equipping is
involved).

We can also broaden our utilization of cost modeling to introduce
alternative assumptions as to the rate at which new items will phase in,
and can determine the impact on required funding levels. We can also
work the problem in reverse, though not as conveniently. For a given
funding level, we can through a process of iteration determine the costs
involved for each of a series of alternative phasing schedules for the
major items. From this we can cull out a number of combinations of
phasing schedules which result in costs within the funding limitation.
In effect then, we have translated a budgetary ceiling into a limited
number of possible major item phasing plans, from which Army planners
can choose the preferred one.

It should be readily apparent that we cannot by a single pass of
the machine translate a given funding limitation into an optimum phasing
schedule for perhaps a hundred items, since Army planners cannot determine
without looking at various combinations what a desirable combination would

be. If an iterative process is in fact necessary, and we strongly believe
it is, the superiority of a machine to a manual process is clear.

To sum up, cost modeling is rapidly establishing itself as indispensable
to planning, and before long, may well become indispensable also for programming and budgeting.